Vol. 4, Issue 2 February 2026 ISSN: 2584-0142

ISSN: 2584-0142
PSYCHOPEDIA JOURNALS
International Journal of Interdisciplinary Approaches in Psychology (IJIAP)

Impact of Cortisol and Other Stress Hormones on Academic Performance among Indian College Students in the Post-COVID-19 Era: A Narrative Review

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Abstract: The COVID-19 pandemic reshaped the mental health landscape and learning conditions of college students worldwide. In India, prolonged lockdowns, online learning, social isolation, health anxieties, and economic uncertainties heightened stress levels among students. Stress triggers neuroendocrine responses, primarily involving hormones such as cortisol, adrenaline, and noradrenaline, which play a critical role in cognition, memory, attention, and emotional regulation [1,2]. Persistent dysregulation of these stress hormones can adversely affect academic performance [3]. Post-COVID studies link elevated cortisol with poorer concentration, sleep disruption, and lower academic outcomes among college students, highlighting the need for hormone-targeted support [8,27,35]. This narrative review examines Indian and global literature on stress hormones and their impact on academic performance among college students in the post-COVID-19 period, highlighting psychosocial stressors, neurobiological mechanisms, academic implications, and intervention strategies relevant to India [4-8].

Keywords: *Stress Hormones, Cortisol, Hypothalamic-Pituitary-Adrenal Axis, Academic Performance, College Students, Post-COVID-19, India, HPA Axis, Neuroendocrine, Biomarkers*

Vol. 4, Issue 2 February 2026 ISSN: 2584-0142

1. Introduction

The COVID-19 pandemic disrupted higher education systems across India, forcing an abrupt transition from traditional classroom learning to online platforms. These changes introduced academic stressors such as digital fatigue, reduced peer interaction, inconsistent assessments, and uncertainty regarding examinations and career prospects [5,9]. For many college students, these challenges were compounded by familial responsibilities, financial instability, limited access to digital resources, and fear of infection [10,11].

Stress reflects the body's integrated psychological and biological reaction to situations appraised as demanding or threatening. Chronic stress activates the hypothalamic-pituitary-adrenal (HPA) axis, leading to prolonged secretion of cortisol [1]. While acute stress may temporarily enhance alertness, sustained stress negatively affects learning, memory, and emotional regulation [2,3]. Post-COVID evidence indicates persistently high stress levels among college students, raising concerns regarding academic outcomes [6,12].

Surveys document high levels of depression, anxiety, and academic distress among college students' post-COVID, with reduced motivation and difficulties in assessments commonly reported [7,8,21]. Few investigations integrate salivary cortisol with academic outcomes in college populations, revealing a key evidence gap that this review seeks to address.

1.1 *Stress Hormones: An Overview*

Stress hormones include cortisol, adrenaline, and noradrenaline. Cortisol, secreted by the adrenal cortex, regulates metabolism, immune function, and cognitive processes [1]. Adrenaline and noradrenaline mediate acute stress responses, enhancing alertness and cardiovascular activity [2]. Under chronic stress conditions, prolonged hormonal activation disrupts circadian rhythm and neural functioning, particularly affecting hippocampal and prefrontal regions essential for learning and memory [3].

Sustained cortisol elevation impairs hippocampal plasticity, slowing information encoding and retrieval, which undermines learning efficiency and exam performance [29, 31]. Dysregulated adrenaline and noradrenaline contribute to test anxiety, tachycardia, and attentional fluctuations during high-stakes academic evaluations [26, 30]. These mechanisms provide a biological foundation for understanding why chronically stressed students often show academic decline.

1.2 *Post-COVID Stressors among Indian College Students*

College students experienced unique post-COVID stressors including delayed examinations, academic backlogs, hybrid learning challenges, and employability concerns [6,9]. Psychosocial stressors such as isolation, fear of illness, bereavement, and financial hardship were widely reported [10,12]. Regional surveys across India demonstrate moderate to severe stress levels in over half of surveyed students during the post-pandemic phase [13,14].

Surveys document moderate to severe stress in most college students, tied to unstable internet access, crowded home environments, and uncertainty about competitive assessments [6,12]. Economically disadvantaged students report higher perceived stress and greater thoughts of discontinuing their studies post-pandemic [11,12].

1.3 *Mechanisms Linking Stress Hormones and Academic Performance*

Elevated cortisol impairs hippocampal neurogenesis and memory consolidation, resulting in reduced attention span and academic efficiency [2, 3]. Chronic stress also affects executive functions mediated by the prefrontal cortex, leading to poor decision-making and decreased motivation [15]. Studies consistently show associations between high perceived stress, anxiety, sleep disturbances, and poor academic performance among college students [6, 12, 16].

Longitudinal data show heightened stress and elevated cortisol during examination periods predict poorer working memory performance and lower scores, indicating a direct biological pathway from neuroendocrine dysregulation to academic decline [17,26,27]. Students with more adaptive cortisol patterns and effective stress regulation demonstrate better study habits and cumulative academic performance [6,12].

1.4 *Evidence from Indian Studies*

Multiple studies conducted during and after COVID-19 report high prevalence of stress, anxiety, and depressive symptoms among college students [6,10,12]. Significant associations between psychological stress and academic performance have been documented in first-year cohorts post-COVID [6]. Increased academic dissatisfaction and psychological distress among higher education students during the pandemic were widely observed [7,11].

Regional investigations across India indicate that many college students entered the post-COVID era with pre-existing psychological distress that remained unresolved despite campus reopening [12]. Direct cortisol measurements remain limited, but longitudinal data suggest

sustained HPA-axis activation under chronic academic stress [17,27,35]. Preliminary findings are compatible with blunted diurnal cortisol variation patterns in stressed student populations [17,27].

1.5 *Long-Term Academic and Health Implications*

Chronic stress hormone dysregulation can lead to burnout, impaired immunity, metabolic disorders, and mental health issues such as anxiety and depression [2,15]. Academically, persistent stress contributes to absenteeism, reduced academic persistence, and higher dropout risk [6,12]. Unaddressed hormonal dysregulation may raise long-term risks for cardiometabolic and psychiatric conditions, affecting post-graduation productivity and employment outcomes [2,15,27].

Chronic stress correlates with reduced persistence in demanding courses and greater likelihood of delayed graduation or program discontinuation. These outcomes pose significant challenges to India's higher education system and future workforce development.

1.6 *Coping Strategies and Interventions*

Institutional interventions including counselling services, academic mentoring, flexible assessments, and mental health awareness program are critical [18]. Traditional practices such as yoga and meditation have demonstrated effectiveness in reducing perceived stress and cortisol levels [19]. Yoga, mindfulness, and physical activity interventions modestly reduce perceived stress and cortisol, with concurrent improvements in concentration and academic engagement [8,19].

Supportive teacher-student relationships, clear communication of assessment criteria, and accessible counselling services buffer the impact of stress hormones on learning outcomes. Encouraging healthy sleep, nutrition, physical activity, and peer support can restore neuroendocrine balance and improve academic engagement.

2. Future Research Directions

There is a need for longitudinal studies integrating biochemical stress markers such as salivary cortisol, hair cortisol, and diurnal cortisol profiles with academic performance metrics including attendance, grade point average, and examination performance. Research should assess the effectiveness of culturally tailored and scalable stress management interventions such as brief relaxation training or institutionalized yoga modules—among vulnerable student populations in higher education settings. Investigation of differential susceptibility based on socioeconomic

Vol. 4, Issue 2 February 2026 ISSN: 2584-0142

status, gender, and academic discipline will help identify high-risk groups requiring targeted support.

The following points may be considered during future research:

1. ***Expanded Biomarker Panels*:** While cortisol is a primary marker, future studies could include a broader panel of stress-related biomarkers, such as alpha-amylase (indicating sympathetic nervous system activity), inflammatory markers (e.g., IL-6, CRP), or heart rate variability (HRV), to provide a more integrated physiological profile of stress.
2. ***Digital Phenotyping and Real-Time Assessment*:** Investigate the use of mobile health (mHealth) technologies, wearable devices, and ecological momentary assessment (EMA) to collect real-time data on stress, mood, and physiological markers alongside academic activities. This can capture dynamic stress-academic performance interactions.
3. ***Evaluation of Digital and Pharmacological Interventions*:** Assess the efficacy of digital mental health interventions (e.g., app-based CBT, virtual mindfulness) and, where ethically and clinically appropriate, explore the role of pharmacological or nutraceutical supports (e.g., adaptogens) in modulating stress hormone responses in student populations.
4. ***Role of Modulating Factors*:** Delve deeper into factors that may buffer or exacerbate the stress-academic performance link, such as:
    a) **Genetic predispositions** (e.g., polymorphisms in stress-related genes like FKBP5, NR3C1).
    b) **Early-life adversity** and its interaction with current stressors.
    c) **Personality traits** (e.g., resilience, perfectionism).
    d) **Specific academic disciplines** with inherently different stress profiles (e.g., medicine, engineering, arts).
5. ***Methodological Rigor*:** Encourage studies with:
    a) **Randomized controlled trial (RCT)** designs for intervention studies.
    b) **Multi-institutional and cross-cultural cohorts** within India to account for regional diversity.
    c) **Mixed methods approach** that combine quantitative biomarker data with qualitative insights into student lived experiences.

6. ***Implementation Science*:** Research the feasibility, acceptability, and scalability of integrating evidence-based stress-reduction protocols (e.g., brief yoga modules, stress literacy workshops) into the routine academic curriculum and campus health services.
7. ***Long-Term Trajectories*:** Examine the long-term academic and career trajectories of students with documented post-COVID stress hormone dysregulation to understand the enduring impact on professional attainment and well-being.

3. Conclusion

The post-COVID-19 era has precipitated a sustained mental health crisis among Indian college students, characterized by an intensification of academic, social, and economic stressors. This narrative review underscores that these stressors trigger prolonged neuroendocrine activation, primarily via the HPA axis, leading to dysregulated secretion of cortisol and other stress hormones like adrenaline and noradrenaline. The consequent biological impact—impaired hippocampal function, compromised prefrontal cortex activity, and disrupted circadian rhythms—provides a direct mechanistic pathway to the observed cognitive deficits, including reduced concentration, poor memory consolidation, and diminished executive function. These impairments fundamentally undermine learning efficiency and academic performance, as evidenced by associations with lower grades, decreased motivation, and higher academic attrition.

The Indian context introduces unique exacerbating factors such as digital inequality, crowded home environments, acute career competition anxiety, and pre-existing psychological distress that remained unaddressed post-lockdown. Crucially, the burden is not uniform; students from lower socioeconomic backgrounds and those without robust support systems are at disproportionately higher risk for both severe hormonal dysregulation and academic decline.

Addressing this multifaceted challenge requires a multi-tiered response. Evidence-based institutional support must move beyond generic counselling to include proactive strategies such as flexible assessment models, structured academic mentoring, and the normalization of mental health discourse. Crucially, interventions should be culturally consonant; practices like yoga and mindfulness meditation show demonstrable efficacy in modulating cortisol levels and enhancing psychological resilience. Promoting foundational health behaviors consistent sleep schedules, balanced nutrition, and regular physical activity constitutes a vital, often overlooked, layer of intervention to restore neuroendocrine balance.

Vol. 4, Issue 2 February 2026 ISSN: 2584-0142

Future efforts must prioritize longitudinal research integrating biochemical stress biomarkers with detailed academic metrics to establish clearer causal links and identify high-risk student profiles. Ultimately, safeguarding the academic potential and well-being of India's future workforce necessitates recognizing chronic stress as a critical public health issue within higher education. By implementing holistic, hormone-aware support systems grounded in both neuroscience and cultural relevance, educational institutions can mitigate the long-term academic and health consequences of stress hormone dysregulation, fostering an environment where students can thrive intellectually and personally.

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